MOLLUSCA OF THE SOUTHWESTERN STATES, V: THE GRAND CANYON AND NORTHERN ARIZONA.

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Prior to 1906 the work on southwestern mollusks of the mountain region had been confined to southern and central New Mexico and Arizona. Between this region and the districts in Colorado and northern Utah which have been explored for snails, a great area, including the Grand Canyon of the Colorado, remained unworked. To obtain some knowledge of this region, the authors spent the month of October, 1906, in the Grand Canyon; also collecting on Bill Williams Mountain (elevation, 9,000 feet), on the plateau of northern Arizona, 64 miles south of the Grand Canyon. In the canyon we collected at the terminus of the Grand Canyon Railroad, a branch of the Santa Fé, at El Tovar, the Bright Angel Trail,[1] and at many localities reached from Bass Trail (also known as the Mystic Spring Trail), 24 miles west of the railroad, and on both sides of the river. Most of our stations here are shown on the accompanying map (fig. 1).

Fig. 1.—Grand Canyon in the vicinity of Bass Trail and Shinumo Creek, showing collecting stations, expedition of 1906. Reduced and simplified from U. S. Geol. Surv. Topographic map, Shinumo quadrangle, edit. of August, 1908.

We did not visit John Hance's trail, the Red Canyon Trail so-called, which lies east of Grand Canyon, the railroad terminus. One species, *Sonorella coloradoensis*, was taken here by Dr. C. Hart Merriam in 1889, but otherwise the snail fauna is unknown. The Grand View Trail is also unvisited by collectors of shells. The Oreohelices and Pupillidæ of the upper and intermediate slopes will doubtless prove interesting

[1] We are indebted to Dr. C. Montague Cooke, of Honolulu, for several species taken by him at the "Indian Gardens," Bright Angel Trail.

and well worth investigation on these two trails, both of which are easily accessible.

In 1909 (August 19 to October 25) Messrs. Ferriss and L. E. Daniels extended the work to the region north of the Grand Canyon, exploring the Powell Plateau and the western side of the Kaibab Plateau, going as far north as Kanab, Utah. A long and hard trip was also made westward to Mt. Trumbull. The route and stations are partly shown in fig. 2. The northward extension of the route, to Fredonia, Ariz. (Station 38), and Kanab, Utah, is not shown on the map. From Fredonia the route led southwest to Pipe Spring, Vermillion Cliff (Station 39), to Yellowstone Spring, southward across Antelope Valley (Station 40), to Mt. Trumbull, where the following stations were occupied:

43, Base of northwestern part of mountain, 6,700 feet.

44, Spring at northwestern part of mountain, 7,000 feet.

45, Northwestern part of mountain, 6,700 feet.

46, Hurricane Fault, 8 miles from Mt. Trumbull, 6,000 feet.

Station 41 is close to the figure 6, on the Kaibab Sheet

Fig. 2.—Part of route and collecting stations, expedition of 1909, north of the Grand Canyon. 1000 ft. contours traced from U. S. Geol. Surv. topographic map, Kaibab sheet, edition of March, 1886, reprinted January, 1900.

Powell Survey, long. 113°, lat. 36° 27′, on a limestone ridge between Finley's reservoir and Mt. Trumbull. Station 42, ant-hills on same road westward.

North of the northern rim of the Grand Canyon only one species of large size was found,—*Oreohelix strigosa depressa* (Ckll.); but this occurs in a multitude of colonies and in great variety of size and color. So far as we know, this form does not occur in Arizona south of the Colorado River in the Grand Canyon. The small shells are for the most part generally distributed on both sides of and in the Grand Canyon. Special to the Grand Canyon, so far as we know, are the following forms:

Sonorella coloradoensis (Stearns).

Oreohelix yavapai, subspecies *extremitatis, angelica* and *profundorum* P. and F.

Pupilla syngenes avus P. and F.

Only the first of these is generally distributed, being found on both sides of the river, and for at least 30 miles along its course; also on the plateau south of the canyon at Bass Station.

The work of collecting in the Grand Canyon is severe. The trails, except the Bright Angel or tourists' trail, are narrow and very steep. You will dig snails on taluses ending in cliffs dropping hundreds of feet; no sound comes back from the rocks your work dislodges. Also, the sandstone and metamorphic rock is hard on the hands. *Oreohelix,* in restricted localities, is sometimes very abundant, but *Sonorella* is always rare, and living ones can be obtained only by hard work. Satisfactory work along the south side can de done from the camps or hotels at the several trails. For work in the lower levels and on the north side of the river a camp outfit and pack animals are required. These may be obtained at the Bright Angel, Bass, Grand View or Hance Trails.

The most productive horizons in the Grand Canyon are the Kaibab Limestone, which forms the slope immediately below the rim, and the talus at the foot of the Cross-bed or Coconino Sandstone, in sheltered recesses where a talus from the overlying limestone terrain has accumulated. The deeper levels are comparatively unproductive, though *Sonorella* penetrates in suitable places nearly to the river.

The molluscan fauna of the Grand Canyon, with the sole exception of *Sonorella,* consists of species inhabiting northern Arizona on one or both sides of the canyon or of forms evidently derived from such species. It must, therefore, so far as mollusks are concerned, be considered a part of the Transition zone. *Sonorella* is the sole Upper Austral genus. It inhabits both sides of the river, up to and even upon the rim.

The canyon forms a barrier to the distribution of *Oreohelix*, the widely spread Arizonian species *O. yavapai* not extending north of it, though very abundant in several subspecies on the southern side, while *O. strigosa depressa*, very abundant north of the canyon, does not to our knowledge occur in the canyon or in Arizona south of it. Some of the smaller species may prove to be similarly restricted, but more copious data are required to prove that this is the case. The minute species, here as elsewhere, are widely distributed, probably owing to the facility with which they may be carried by cyclonic storms.

In a former paper of this series[2] we discussed briefly the relation of desert snails to their environments, concluding that the direct influence of desert climate had been overestimated basing this opinion upon the fact that these animals are quiescent except during the brief periods of damp or rainy weather; and accounting for the opaque and chalky texture of exposed snails as a protection against sunlight, probably brought about by selection. A recent letter from Dr. Wm. H. Dall, giving his somewhat diverse views upon the same topic, is here printed, by permission, so that those interested in these questions from the standpoint of molluscan study may have both views before them.[3]

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[2] Mollusca of the Southwestern States, IV: The Chiricahua Mountains, *Proc. Acad. Nat. Sci. Phila.*, 1910, pp. 47–50.

[3] "In regard to direct action of sunlight and other factors of climate on desert snails (among which I reckon only those really exposed to it, and not those like *Ashmunella*, which by descending into the rock piles reach a moderately humid climate), my reasoning would be something like this: We know irritation of the surface in snails causes exudation of mucous matter (mixed with lime in the case of shell bearers), which tends to thicken and incidentally to contract or corrugate new growth, this irritation may be alkali in fresh waters, sand or infusoria in pearl oysters, alkali dust on arid windy volcanic islands, like the Galapagos or St. Helena, and scorching sunlight in desert places. Now the first result would be to thicken the shell and exclude the irritant, otherwise the animal will die. Assuming that before reaching the point of absolute exhaustion the amount of mucus has a limit, this means a retardation of growth in the spiral direction, and if (assuming that the color glands have also a limited amount of color to give the general secretion) it would be, in the case cited, abnormally diluted; with the result that the shell would tend to be whiter than the normal, *not as a protection*, but because of the dilution. This explains the white Bulimini, Clausilias and Pupas, so conspicuous on hot rocks in South Europe. Then comes in Natural Selection by killing off those which did not or could not sufficiently thicken themselves to ward off the light, and you have by the most simple direct action, without any heredity being called into play (unless through some transmission of acquired characters, which I regard in this case as very doubtful) all the characteristics of desert snails over the whole world developed in the individual by direct action.

"In the Galapagos snails the young nepionic whorls are normal, and I believe would continue so except for the direct action of the environment. This affects those on the ground, grass and low shrubs. Those living on the higher trees escape (by my hypothesis) the dust and continue or remain normal in their growth."

List of Species.

HELICIDÆ.

Sonorella coloradoensis (Stearns). Pl. XII, figs. 26–30.

Helix (*Arionta*) *coloradoensis* Stearns, Proc. U. S. Nat. Mus., vol. XIII, p. 226, pl. 15, figs. 6, 8, 12, 1890.

Sonorella coloradoensis Stearns, Pilsbry, Proc. Acad. Nat. Sci. Phila., 1900, p. 560. 1901. Bartsch, Smithsonian Misc. Coll., vol. XLVII, p. 189, pl. 32, fig. 3 (shell of type), 1904.

The type specimen of this species measures: alt. 10, diam. 16.4 mm., umbilicus about 1.8 mm. The locality given by Stearns and repeated by Bartsch,[4] Grand Canyon of the Colorado opposite the Kaibab Plateau, alt. 3,500 feet, is somewhat indefinite, on account of the considerable extent of the Kaibab Plateau. Dr. C. Hart Merriam, to whom we applied for further details, writes: "I collected the type of *Helix coloradoensis* Stearns in September, 1889, in the Grand Canyon below the tank then known as Canyon Spring, not far from where John Hance afterward built what is known as the Hance Trail. At that time neither the Bright Angel nor Bass's Trail had been heard of."

This locality is, properly speaking, opposite what is now known as the Walhalla Plateau, not the Kaibab Plateau.[5] As the river flows, it is about 13 miles east of the Bright Angel Trail, and 30 miles east of Bass's Trail. Owing to the sinuosity of the sides of the canyon, the actual distance along any level above the river gorge and below the rim would be at least three or four times as great.

The specimens from the Bright Angel and Bass's Trails and from the north side differ from the type by having the umbilicus slightly larger.

The soft anatomy of the type was not described. One of us has dissected specimens from both sides of the river at Bass's Trail. The genitalia of a shell from "Spectacle Cove" (Station A) figured (fig. 3A) show the species to be a true *Sonorella*, related about as nearly to the forms found in the region immediately south of Tucson, as to any southern species. The penis (*p.*) is swollen distally, narrow in its basal half, where it is enveloped in a rather long muscular sheath. It contains a tapering papilla (*p.p.*), not quite half as long as the penis. The epiphallus (*epi.*) is about equal to the penis in length, slightly larger than the vas deferens. There is no flagellum. The penis

[4] The localities for *S. coloradoensis* in Inyo and San Diego Counties, California, which Dr. Bartsch credits to Pilsbry and Johnson, were taken by them from a paper by Dr. Stearns, *Nautilus*, VIII, p. 29. This paper was not noticed by Dr. Bartsch, who has shown that the shells in question are not *S. coloradoensis*.

[5] See U. S. Geol. Survey Topographic Map, Vishnu Quadrangle.

retractor muscle inserts on the epiphallus. The vagina is rather short and slender. Atrium longer than usual in *Sonorella*. Length of the penis, 4.5 mm.; penis-papilla, 2 mm.; vagina, 3 mm.; spermatheca and duct, 21.5 mm.

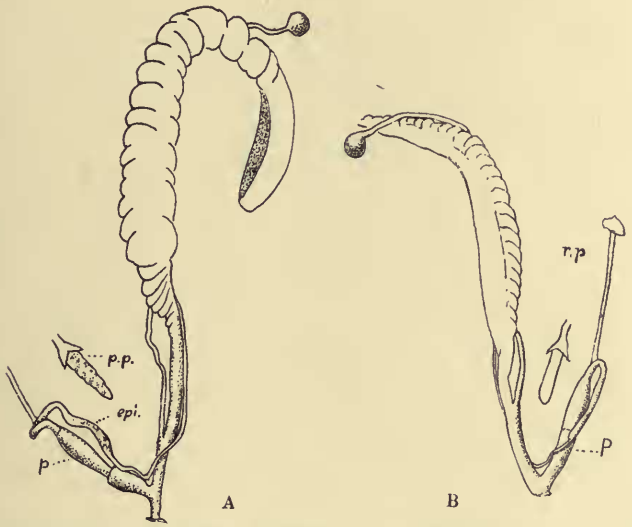

Fig. 3.—Genitalia of *Sonorella coloradoensis*. *A*, Spectacle Cove. *B*, bandless form from White Creek, Station G.

A specimen of the bandless form from White Creek, a branch of Shinumo Creek, shows only slight differences in the genitalia from the "Spectacle Cove" form. The atrium is shorter; penis-papilla more cylindric and blunter. Length of penis, 5 mm.; epiphallus, 4.7 mm.; penis-papilla, 2 mm.; vagina, 3.8 mm.

While *S. coloradoensis* seems to be generally distributed in the Grand Canyon, the colonies, except near the rim, are isolated and mostly small. Except during wet weather, the snails adhere to eruptive or metamorphic rocks, making white circles thereon like other Sonorellas. Specimens were taken by us at the following places:

(*South side of the Colorado River.*)

(1) Bass's Station, on the Grand Canyon R. R., about four miles south of the Grand Canyon. The shells vary from alt. 10.5, diam. 16 mm., to alt. 9.8, diam. 15 mm.

(2) Upper talus along the Bright Angel Trail from 100 to 400 feet below the rim. The specimens are like those from Spectacle Cove, noticed below.

(3) Station C: Upper talus-slope in the bay about ½ mile west of Bass Camp, a few hundred feet below the rim. The shells here are small, alt. 8, diam. 13, width of umbilicus 2 mm. None found alive. In some examples the shoulder-band is extremely faint, but in most of them it is distinct.

(4) Station A: "Spectacle Cove," an embayment at the foot of the cross-bed or Coconino sandstone, in a talus resting upon the Aubrey red sandstone, with *Oreohelix yavapai profundorum.*

Specimens measure:

Alt. 10, diam. 16.0, umbilicus 2.1 mm.
" 9, " 14.8, " 2.0 "

All have a band at the shoulder. Very few living adults were taken, but, unlike the *Oreohelices,* the shells are entirely normal.

(5) Seep Spring, 2 miles west of Bass Trail, at base of the cross-bed sandstone. Shells like the preceding lot from the same level.

(6) Station B: Head of Starvation Tank Wash, around the point to the right from Bass Trail, at about 5,800 feet elevation (Pl. XII, figs. 29, 30).

(7) Station D: Bass Trail, on the Red Wall, 5,000 feet.

Alt. 10.1, diam. 16, umbilicus 2.1 mm.
" 9.5, " 16, " 2.1 "
" 9.1, " 15, " 2.1 "

The shoulder-band is wanting in about half of the shells taken.

(8) Station E: Foot of Red Wall, on Bass Trail, elevation about 3,850 feet. Like the preceding, diam. 15 to 16.3 mm. A few "bones" were taken still lower, at about 3,000 feet, in a talus of the Red Wall limestone.

Alt. 8.9, diam. 15.0, umbilicus 2.0 mm.
Fig. 29. " 9.0, " 14.3, " 2.0 " ; whorls 4½.
" 8.5, " 13.6, " 1.9 "
" 8.2, " 13.5 mm.

The corneous, brown shell is more or less streaked with white and invariably has a narrow band at the shoulder.

(*North Side of the Colorado River.*)

(9) Station F: Shinumo Creek, near camp, elevation about 2,500 feet.

Alt. 10.8, diam. 16.9, umbilicus 2.1 mm.; whorls 4½.
" 10.8, " 16.5, " 2.1 "
" 9.3, " 15.1, " 2.0 "

Similar shells occurred at Station 3, Shinumo Box, 2,750 feet,

the largest, alt. 12, diam. 17.2, umbilicus 2.5 mm. (F. and D. 1909). Some of these shells are the largest taken up to this time, exceeding the types. The shoulder-band is faint or wanting on some shells.

(10) Station G: White Creek, about 1 mile above its confluence with Shinumo Creek (Pl. XII, figs. 26–28). Seven per cent. of the shells taken show a chestnut band. In the rest there is an ill-defined whitish band in its place. Bandless shells are rare in all other localities. The aperture is also more ample in this lot, *somewhat trumpet-shaped*, the lip is rather more thickened and rusty, and the parietal callus is generally thick at the edge.

Alt. 10, diam. 17.0, umbilicus 2.6 mm.; aperture 8.8 x 10.0 mm.
" 10, " 16.2, " 2.1 " " 8.2 x 9.5 "
" 9, " 15.2, " 2.25 " " 8.0 x 8.8 "

The genitalia of a specimen of this lot are figured, fig. 3*B*.

(11) Muav Box, Station 9, elevation 4,000 feet (F. and D., 1909). Diam. 15–16 mm. All taken have the shoulder-band.

(12) Station H: Mojave Amphitheatre below the red-wall sandstone (west side of Muav Canyon, near Dutton's Point). The shells are all banded, measure 14 to 16 mm. diameter, and do not seem to differ from those taken on the Shinumo at a much lower elevation. At this point the authors made a dry camp in 1906, being unaware that there was water a few miles beyond. In 1909 Ferriss and Daniels took a fine lot of unusually large and dark colored Sonorellas at Station 107, about two miles farther up Muav Canyon, but they were lost before reaching home.

(13) Station 104, 6,700 feet, and Station 9, 7,500 feet, east side of Powell Plateau (west of Muav Wash). Small, 13.5 to 14 mm. diam.; banded; *aperture dilated*, as in the shells described under (10). This colony and those following were taken by Ferriss and Daniels, 1909.

(14) Station 5, east of Muav Canyon, near the Kaibab Saddle, 6,717 feet. Small shells, diam. about 13.5 to 15 mm., with the mouth less dilated than in the preceding lot, nearly normal. All are banded.

(15) Station 25, west side of Powell Plateau, 6,700 feet. The shells are small, diam. about 14 mm., with thickened lip and somewhat dilated mouth, as in Nos. (13) and (19).

(16) At Station 23, Horse Tank Canyon, on the west side of Powell Plateau, 7,000 feet, the shells are like those from No. (12). Some bandless individuals were also taken.

(17) Station 101, north end of Powell Plateau, 6,700 feet. Only dead and bleached shells, normal in shape.

(18) Station 100, third amphitheatre north of the Kaibab Saddle,

6,700 feet. Shells 14 to 15 mm. diameter, normal in shape and color, similar to lot No. (10). This is farthest north for the species.

Oreohelix yavapai profundorum n. subsp. Pl. XII, figs. 1–14.

The shell is *opaque-white* with some brownish, corneous streaks and often two fleshy, brown bands, the inner whorls more or less flesh-tinted; *solid;* with sculpture of rather wide, irregular, subobsolete growth-wrinkles, but *no spiral striæ.* Whorls 4½ to 5, the last angular or subangular in front, *descending* moderately or deeply to the aperture, often becoming shortly free. Aperture very oblique or subhorizontal, the peristome slightly thickened and brownish, continuous and free or in contact with the preceding whorl for a short distance.

Fig. 1. Alt. 12.0, diam. 14.8 mm.
" 2. " 12.2, " 13.8 "
" 3. " 11.5, " 16.7 " ; umbilicus 3 mm. wide.
" 4. " 11.2, " 17.3 "
" 5. " 9.5, " 17.2 " ; umbilicus 4.5 mm. wide.
" 10. " 9.0, " 13.2 " " 2.9 " "

Adult shells measure from 13 to 17½ mm. diameter.

The genitalia are figured (fig. 4). The lower half of the penis is much swollen, the upper half slender and cylindric, the retractor muscle inserted at its apex. The short epiphallus is rather stout. Vagina short and very large. The uterus in the individual figured contained four embryos; the shells 4.7 mm. in diameter, with 2¾ whorls and acutely carinate periphery. The podocyst is larger on the upper embryos, but present in all.

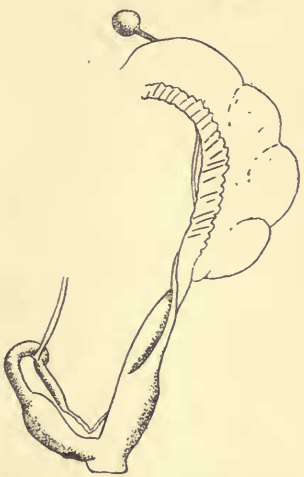

Fig. 4.—*Oreohelix yavapai profundorum.*

Length of penis, 6.7 mm.; epiphallus, 3 mm.; vagina, 4 mm.; spermatheca and duct, 17 mm.

Out of 100 shells from the type locality, taken at random, 56 per cent. resemble figs. 1–3, 44 per cent. being like figs. 4, 5. The race is therefore markedly senile.

Grand Canyon, in "Spectacle Cove," Station A, the head of a recess in the cross-bed sandstone south of where the Mystic Spring or Bass Trail zigzags down, in a talus resting on the red sandstone forming the Le Conte Plateau. Elevation about

5,700 feet. Cotypes, No. 103,234 A. N. S. P., collected by Ferriss and Pilsbry, October, 1906.

The embryonic shell, of 2¼ whorls, shows fine subregular ripples along the lines of growth, and in places some fine, very faint spiral striæ may be traced; on the base these spirals are more distinct. They continue there during the first part of the neanic stage, but disappear after a diameter of 8 or 9 mm. has been attained. The main spirals are widely spaced, as in *O. yavapai*, but at all stages of growth they are very weak. The embryonic shell is light brown. Some maculæ and streaks of opaque cream-white appear after the third whorl. In the adult stage the surface becomes dull white and somewhat chalky from loss of the very thin cuticle, which is present in the embryonic and early neanic stages.

O. y. profundorum and the allied races, *extremitatis* and *angelica*, differ from *O. yavapai* by the very weak spiral striation of the embry-

Fig. 5.—Spectacle Cove (Station A), from opposite side below Bass Trail. Type locality of *Oreohelix yavapai profundorum* on the mound at left end of talus slope.

onic shell. *O. profundorum* resembles *O. yavapai*, *O. y. neomexicana* and *O. borbata* in having a very short penis, its length about half the diameter of the shell or less. In the *strigosa* group, so far as known, the penis is long, two-thirds the diameter of the shell or more, in alcoholic examples. *O. yavapai*, *neomexicana* and *profundorum* are alike in genitalia, but *O. borbata* differs by having the retractor muscle inserted on the epiphallus, whilst in the others it is inserted at the apex of the penis.

The type locality of *O. y. profundorum* is in an embayment of the cross-bed sandstone, where a talus at its foot rests upon the red sand-

stone. Living specimens were taken only on the last mound of the talus at the head of the wash, shown on the left in fig. 5. This mound is about 30 or 40 feet high, about 100 feet long, and has a great rock in the middle. Dead shells were scattered over the talus for about 200 yards westward, nearly as far as the large rocks shown in the edge of the piñons. Except where piñons are shown, the slope is covered with shrubs. The Oreohelices live among moss and grass, around and under stones in great profusion. With them live *Cochlicopa, Pupilla,* etc., and *Sonorella coloradoensis,* the latter found over the whole talus shown in fig. 5, but everywhere very scarce. Numerous other taluses at and below the same level were searched, but no other colony of *Oreohelix* was found. All other colonies of *Oreohelix* seen are on the upper slopes only a short distance below the rim of the canyon.

In the absence of any source on the lower levels, *O. y. profundorum* must have been derived from *O. y. extremitatis,* which inhabits the slope above the cross-bed sandstone, whence individuals have fallen into the abyss. The considerable divergence of the race on the lower level, and the fact that only one colony was found at that level, seem to indicate that most snails which are carried or fall over the cliff do not survive the terrific drop of several hundred feet.

In the series of several thousand shells taken there was one sinistral example.

That the colony of *O. y. profundorum* is decadent seems to be indicated by the fact that dead shells were found over an area many times greater than that now inhabited by living snails. The markedly senile character of the shells also foretells approaching extinction. Yet the local conditions appear altogether favorable and living individuals are very abundant in a limited area.

Oreohelix yavapai extremitatis n. subsp. Pl. XII, figs. 15–21.

At Station 2, near Bass's Trail, about 200 feet below the rim of the Grand Canyon, the Oreohelices (pl. XII, figs. 18–21) are *more depressed* than *O. y. profundorum,* less solid and less calcareous, invariably two-banded. The surface is more or less suffused with light brown, especially on the spire, and the very thin pellucid cuticle is retained, so that the shell has a slight luster. The embryonic whorls are like *profundorum;* the first third or half of the last whorl is *acutely carinate* in front, and the latter part descends very little (as in fig. 18, 67 per cent. of the shells examined) or somewhat deeply (fig. 19, 33 per cent.). *Widely spaced granose spirals* (such as are characteristic of *O. yavapai*)

are visible on the base in front of the aperture in most of the shells. The aperture is contracted less than in *O. y. profundorum* and the peristome is not thickened. The largest examples measure, alt. 8.2, diam. 16 mm., the smallest alt. 8.3, diam. 14 mm. About 60 adults examined.

Fig. 18. Alt. 8.0, diam. 15.8 mm.; width of umbilicus 4.7 mm.
" 19. " 7.8, " 14.5 " " " 4.0 "
" 19. " 8.7, " 14.2 " " " 4.0 "
" 20. " 8.5, " 16.0 " " " 4.3 "
" 21. " 8.0, " 15.5 " " " 4.3 "

Cotypes are No. 103,236 A. N. S. P., collected by Ferriss and Pilsbry, 1906.

Similar shells occur on the upper slope at the same level, in a bay of the rim, about a half-mile west of Bass's Camp, on the southern rim of the canyon (pl. XII, figs. 15, 16, 17).

Fig. 15. Alt. 9.2, diam. 15.5 mm.; umbilicus 4.0 mm. wide.
" 16. " 8.1, " 15.1 " " 4.1 " "
" 17. " 9.0, " 16.9 " " 4.9 " "

Oreohelix yavapai angelica. Pl. XII, figs. 22–25.

On the Bright Angel Trail, at Grand Canyon, from 100 to 400 feet below the rim, which has here an elevation of 6,866 feet, the shells resemble *O. y. extremitatis* in contour, except that the last whorl is somewhat more inflated. The color is light brown, usually with a brown band below the periphery, sometimes with another above, but this is often wanting. It is thinner and larger than *extremitatis*, and spaced spirals are more distinct, being well-developed on both the base and upper surface. The embryonic whorls have faint spiral lines. The first part of the neanic stage (up to at least 11 mm. diam., with nearly 4 whorls in some individuals) bears *spiral rows of cuticular scales* readily visible to the naked eye. There are about 8 spirals above, 10 below the periphery on the last whorl. The last whorl is but slightly deflexed in most examples, rarely (8 per cent.) more or less deeply so, approaching fig. 25, which is an extreme individual.

Fig. 22. Alt. 9.0, diam. 17.0 mm.; width of umbilicus 4.5 mm.
" 23. " 9.2, " 17.0 " " " 4.9 "
" 24. " 9.2, " 17.9 " " " 4.8 "
" 25. " 10.2, " 16.0 " " " 3.8 "

Individuals with deeply descending last whorl occurred chiefly at the lower level.

Alt. 9.5, diam. 18.3 mm.
" 10.2, " 17.0 "
" 8.0, " 16.0 "
" 9.8, " 16.0 "

This race occupies the same zone as *O. y. extremitatis*, in the Kaibab limestone. The stations are about 20 miles apart, but including the windings of the canyon, as the snail travels, the distance would be far greater. The embryonic stage is very much alike in *O. y. profundorum*, *extremitatis* and *angelica*, but the neanic and adult stages differ.

Cotypes No. 103,239 A. N. S. P., collected by Pilsbry and Ferriss, 1906.

Oreohelix strigosa depressa (Ckll.). Pls. XIII, XIV.

[*Patula strigosa*] var. *Cooperi* Binney, Manual Amer. L. Shells, p. 166, fig. 153 (teste Ckll.).
Patula strigosa cooperi var. *depressa* Ckll., Nautilus, III, p. 102, January, 1890, canyon near Durango, Colo.
Oreohelix strigosa Gld., Pilsbry, Proc. A. N. S. Phila., 1905, p. 272, pl. XXV, figs. 45–47 (shell); pl. XI, figs. 14, 15 (embryonic shell); pl. XIX, fig. 3 (genitalia); pl. XXII, figs. 1–3 (teeth); pl. XXIII, fig. 25 (jaw).

New Mexican examples of *O. s. depressa* have been fully described and figured in a former paper of this series. In the country north of the Grand Canyon it is an abundant snail, varying widely in size, form, color, and to a less degree in sculpture not only in different colonies, but frequently among individuals of one colony.

In some districts, as along the western escarpment of Powell Plateau, there is a marked tendency to lose the dark bands. In some other places beautiful albino shells occur in colonies composed chiefly of well-colored shells. There is a tendency in many places to produce more compactly coiled shells than typical *depressa*, the spire being higher and the total diameter and the umbilicus smaller in some of the shells. This culminates in a form of shell which is not distinguishable from *O. cooperi*, found in a few stations.

In some arid situations, especially the head of Quaking Asp Canyon, the shells are conspicuously dwarfed, their development arrested. No colonies are markedly gerontic, though in a few there is a tendency towards senile characteristics in occasional individuals.

The spiral sculpture is generally distinctly developed, and sometimes some larger, widely spaced spirals can be seen on the base of the shell.

Specimens are illustrated on Plates XIII and XIV. Some

comment on the several lots follows, beginning at the northern stations.[6]

(1) Jacob's Canyon (Pl. XIII, figs. 1–5), Oreohelices were taken at Stations 68, 69, 70, 71. The typical form and coloring (fig. 1) prevail, but there is also one color-form not elsewhere encountered, in which the bands are purple-brown and very wide, the upper one spreading to the suture or leaving a white belt below the latter (figs. 2–4). There are also some pearl-white and dirty white shells (fig. 5). The same color-forms occurred at Station 67, below the mouth of

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[6] Only one of us (Ferriss) collected *P. S. depressa* north of the Grand Canyon, being accompanied there by Mr. L. E. Daniels. His impressions concerning the relations of shell-characters to the environmental factors of elevation, humidity and direction of slope are given below. It must be remembered that the conditions in the Kaibab region are less accentuated than in the more arid mountains of the south.

"At the time our observations in 'Mollusca of the Southwestern States, No. IV,' were written, environment seemed the controlling factor in the determination of size of the shell, northern exposures, with an abundance of shade and plant life and a longer growing season, would produce the larger shells. In the region north of the Grand Canyon many apparent exceptions to this rule were noted. Often colonies of the same species but 100 feet apart varied 100 per cent. in size. In a gulch facing north in the Powell-Kaibab saddle, in a box canyon with perfect snail conditions, the *Oreohelix* average 20 mm. in diameter. Above the box, in a more open country, they average 24 mm. and were more plentiful.

"In the canyons and amphitheaters of these plateaux, with the same exposure, moisture, shade, elevation—mineral, plant and all other conditions equal so far as we could understand—each colony stood out by itself in color, size and shape of the spire. These qualities seemed subject to mutation rather than controlled by environment.

"Thus, in Two-Spring Canyon, the shells in a colony on one side of a rock were 25 per cent. larger than those of the colony upon the other side, less than 100 feet distant; and a colony on the west side of the stream, no farther away, was larger than either. In the center of a colony on Powell Plateau, a 'family' of larger shells was found.

"Until we crossed the Kaibab Plateau, the collections of 1909 were at about the same elevation, in the limestone section. In Two-Spring and Quaking Asp Canyons, both heavily wooded, the Oreohelices at the top, among the quaking asp, were 14 mm. in diameter, gradually increasing in size, as we descended, to 25 mm., as would naturally be expected.

"In Snake Gulch, however, the largest shells were at the top, on slopes facing either north, west or south, the diameters running 25 and 26 mm. at Castle Springs and vicinity. At Big Springs, with abundance of shade and humidity the year around, and a warm *southern* exposure, the largest measurements were 21, and at the lowest colony in the gulch less than 18 mm.

"In Warm Springs Canyon, running from east to west parallel with Snake Gulch, the smaller colonies were midway in the canyon, those at both the top and bottom of the canyon being unusually large and robust, and it was the same in Jacob's Canyon, another parallel canyon of this group running to the west.

"We collected Oreohelix at 22 stations, elevation about 6,700 feet, in the saddle region of the Powell and Kaibab Plateaux; at 19 stations in Two-Spring and Quaking Asp Canyons in the Kaibab Plateau, at elevations between 6,500 and 8,250; at 20 stations in Snake Gulch, Kaibab Plateau, from 5,000 to 7,000 feet elevation; at 16 stations in Warm Spring and Jacob's Canyons, Kaibab Plateau, from 6,000 to 6,750 feet elevation."

Jacob's Canyon, in the second gulch north of Warm Spring Canyon. It was not noticed at Station 68.

Fig. 1. Alt. 12.8, diam. 23.0, umbilicus 5.9 mm.
" 2. " 11.8, " 22.3, " 6.1 "
" 3. " 11.3, " 22.7, " 6.0 "
" 4. " 12.5, " 21.8, " 6.0 "
" 5. " 11.8, " 24.0, " 6.1 "

(2) At Station 66 (Pl. XIII, figs. 6, 7), in the first gulch facing west, north of Warm Spring Canyon, the shells are smaller and usually more elevated, the last whorl at the aperture generally falling well below the lower band. Color and sculpture are normal.

Fig. 6. Alt. 12.0, diam. 19, umbilicus 5.0 mm.
" 7. " 10.5, " 17, " 4.6 "

(3) In the head of Shinumo Canyon (Pl. XIII, figs. 10, 11, 12), Stations 50, 51, 52, the shells are typical in form, but a majority of them have the bands weak, or one or both may be absent (figs. 10–12, Station 50, 5,500 feet elevation). Farther west, at Station 53, the bands are somewhat stronger. Beyond this, going west, the shells are smaller (Stations 54, 55, 56, 57), the last whorl falls more, and the ends of the lip approach—senile characters, doubtless indicative of unfavorable conditions leading to decadence of the race (Pl. XIII, figs. 13, 14, Station 55, at 5,500 feet).

Fig. 10, diam. 20 mm. Fig. 11, diam. 19 mm. Fig. 12, diam. 17.7 mm. (Station 50).

Fig. 13. Alt. 9.2, diam. 15.7 mm. (Station 55).
" 14. " 7.8, " 14.5 " umbilicus 4 mm.
" 15. " 9.2, " 15.7 "

(4) Moquitch Gulch, Stations 75, 76 (Pl. XIII, figs. 16–18). The shells are of medium size, more or less brown, with typical bands. An albino form, white with greenish, translucent bands, appears here.

Fig. 16. Alt. 11.7, diam. 18, umbilicus 3.9 mm. (Station 76). Fig. 17. Diam. 17.3 mm. Fig. 18. Diam. 18.8 mm. (Station 75).

(5) Continuing southward on Snake Gulch, we encounter snails essentially like those from Stations 49, 50 and 37 in Stations 35, 34, 33. At Station 78, boldly marked two-banded shells and beautiful albinos occur, as already figured from Moquitch Gulch. At Stations 32 and 77 most of the shells are large and dark, but a few are small.

(6) Warm Spring Canyon (Pl. XIII, figs. 8, 9). Finely developed shells occur at Stations 59, 60, 61, 62, 64, 65 and 73 or 74, mostly with the normal color-pattern, but sometimes the bands are weak or almost absent, chiefly in shells from Station 61.

At Station 60 only fossil examples were taken.

Fig. 8. Alt. 9.8, diam. 21.0, umbilicus 6.5 mm. (Station 62).
" 9. " 11.0, " 22.7, " 6.3 " (" 61).

(7) At Snake Gulch, below the Coconino Smelter, Station 49, the shells resemble those from Station 66, having a low conoidal spire and depressed last whorl which falls decidedly at the aperture. Bands narrow, rather pale.

(8) At Station 37, Snake Gulch, at the north side of the mouth of Smelter Gulch, elevation 5,750 feet, the shells resemble those from Station 50 (see fig. 11).

(9) At Castle Springs, Station 79, the shells are large and dark, two-banded or more or less clouded (Pl. figs. 19–21, 6,750 feet elevation). Similar examples are found at Riggs Spring, Station 81.

Fig. 19. Alt. 11.8, diam. 20.0 mm. (Station 79).
" 20. " 13.5, " 23.8 " umbilicus 6.2 mm. (Station 79).
" 21. " 12.0, " 23.2 " " 5.3 " (" ").

Between the preceding and following stations there is an interval of about 13 miles over the watershed in which no Oreohelices were found.

(10) Quaking Asp Canyon penetrates the Kaibab Plateau from the west, where it drains into Tapeats Creek. Two-Springs Canyon is a branch of the head of Quaking Asp. From the lower end of Quaking Asp Canyon, Station 98, 6,500 feet elevation, to the head, Station 83, 8,250 feet, there is a gradual diminution in size of the shells, no doubt due to increasing aridity of the higher stations westward.

At Station 98 the shells are very large, diam. 22 to 26 mm., but typical in form and color (Pl. XIII, figs. 24–26). At Station 97 the size averages smaller, and there are some albino shells, white with translucent, greenish bands. At Stations 99, 96, 94, 93, 92, 91, 90, 89, 87, 88 there are similar shells, the size diminished a little (Pl. XIII, figs. 22, 23, Station 91, 7,000 feet).

Stations 86, 85, 84 and 83 show shells still further diminished, adults measuring, alt. 9 diam. 14 to alt. 7, diam. 11.5 mm., with 4½ whorls (Pl. XIII, figs. 27, 28, Station 84). The color is typical; the periphery angular in front and the last whorl descends only very little to the aperture. These colonies show no senile features. Their development has been arrested, the small number of whorls and the angular periphery being characters of youth.

At Two Springs, Station 27, the shells resemble those from Station 91. Farther up the canyon, Station 26, the shells became smaller,

adults measuring 12 to 15 mm. diam., as in the head of Quaking Asp Canyon.

Fig. 22. Alt. 12.0, diam. 19.3, umbilicus 4.5 mm. (Station 91).
" 23. " 11.2, " 16.8, " 3.8 " (" ").
" 24. " 14.0, " 24.5, " 6.3 " (" 98).
" 25. " 13.0, " 21.0, " 5.8 " (" ").
" 26. " 15.0, " 25.0, " 6.0 " (" ").
" 27. " 7.0, " 11.5, " 2.9 " (" 84).

(11) At Station 100, Kaibab-Powell Saddle, 6,700 feet, the shells resemble those figured from Station 98, but are smaller, diam. 17.5 to 21 mm.

(12) Off the north end of Powell Plateau, at Station 17 (Pl. XIV, figs. 1–4), there is wide color-variation in the colony, the following forms occurring:

Figs. 1, 3. Typical two-banded form, diam. 18 to 21 mm.
Fig. 2. Upper band obsolete, the lower are weak same sizes.
Fig. 4. White, with greenish, translucent bands, diam 19 mm.

(13) In other stations at the northern end of Powell Plateau, 13, 14, 15 (but not Station 16), and Station 105, near Oak Springs, the prevalent form (Pl. XIV, figs. 6, 7, 8) Station 15, 6,500 feet) is rather less depressed than typical *depressa*, though the depressed form also occurs (Pl. XIV, fig. 5, same station). At Stations 13, 15 and 105 some examples are not distinguishable from *O. cooperi* (Pl. XIV, fig. 9, Station 15; fig. 23, Station 105); yet some examples seem to connect with normal *depressa*. At Station 18, at 6,700 feet, two adult shells (Pl. XIV, figs. 10, 11) are of the *cooperi* form.

Fig. 10. Alt. 12.0, diam. 18.7, width of umbilicus 4.5 mm.
" 11. " 11.9, " 18.0, " " 4.0 "

The material from these stations (13, 15, 18) is too scanty to decide with certainty whether the series is divisible into *cooperi* and *depressa* or whether the globose specimens are inextricably connected with the *depressa* stock of the region. Except at Station 18, the *cooperi* form occurs with undoubted *depressa*, as at Station 105, where figs. 22 and 23 of Pl. XIV occurred together.

(14). The west side of Powell Plateau, Stations 25, 24, 22, 21, 20, 19, and Station 16 at the north end, have a somewhat different race. There are typical two-banded *depressa* (Pl. XIV, figs. 13, Station 16) and also specimens lacking one or both bands (Pl. XIV, figs. 14, 15, Station 16, 6,700 feet; fig. 16, Station 19).

The specimens vary from quite large, diam. 25, to medium size,

diam. about 19 mm. At Station 16, 80 per cent. of the shells are bandless.

(15) On the east side of the Powell Plateau, Stations 10, 103, 8, 12, the shells are typical two-banded *depressa* (Pl. XIV, figs. 17, 18, 19, Station 103, 6,700 feet) varying to forms with the spire higher (figs. 20, 21, same station). Fig. 21, alt. 12.3, diam. 18, umbilicus 4 mm.

Thysanophora ingersolli (Bld.).

Bill Williams Mountain; Two-Spring Gulch, Kaibab Saddle.

Thysanophora hornii (Gabb).

Shinumo Creek, on the north side of the Grand Canyon. Farther north than this species has been reported hitherto.

ENDODONTIDÆ.

Pyramdula (Gonyodiscus) cronkhitei (Newc.).

Bill Williams Mountain. It was not found in the Grand Canyon, but north of it was taken at Castle Springs and Rigg's Spring, Snake Gulch, Kaibab Plateau; Mt. Trumbull; also Deception Lake and Crocodile Lake near Kanab, Utah, 5,500 feet elevation.

ZONITIDÆ.

Vitrina alaskana Dall.

V. Pfeifferi Newc. not of Desh.

Living specimens were taken on Bill Williams Mountain. Numerous dead shells were found near a small spring in the Grand Canyon below the cross-bed sandstone, 2 miles west of Mystic Spring Trail. This spring is called Seep Spring on the topographic map, Shinumo quadrangle. The average size of adults here seems to be about 6 mm. diam., but one shell measures 7.4 mm. We did not find *Vitrina* elsewhere in the Grand Canyon, but northward it occurred at Warm Spring Canyon and Rigg's Spring, Kaibab Plateau, and at Mt. Trumbull.

The living animal observed October 15, at Bill Williams Mountain, is far less voluminous than *V. limpida*. There is one small shell-lobe, covering the termination of the suture. In progression the tail does not project behind the shell.

Vitrea indentata umbilicatae 'Singl.' Ckll.

Bill Williams Mountain. Grand Canyon along the Bright Angel Trail from just below the rim to the base of cross-bed sandstone and at the Indian Gardens; Bass Station, Grand Canyon R. R.; Station H, on the north side of the canyon. Also taken on the north side of

the Grand Canyon on Powell Plateau; Kaibab-Powell Saddle; Castle Springs, Snake Gulch; Two Springs, Kaibab Plateau.

Euconulus fulvus alaskensis (Pils.).

Bill Williams Mountain. Grand Canyon, Bright Angel Trail, from just below rim to base of cross-bed sandstone. Mystic Spring Trail about 200 feet below rim, and Station C, about a half-mile west of Bass's Camp; "Spectacle Cove," Station A. North of the Grand Canyon; Powell Plateau, Station 18; Kaibab Saddle and plateau at Stations 5, 7, 12, 66, 100; Riggs Spring, Snake Gulch; Castle Springs; Warm Spring Canyon; spring on the northwest side of Mt. Trumbull.

Zonitoides milium meridionalis Pils.

Bill Williams Mountain.

Zonitoides minuscula (Binn.).

Bill Williams Mountain. Base of Mt. Trumbull.

Zonitoides arborea (Say).

Bill Williams Mountain. Snake Gulch, Station 11½.

LIMACIDÆ.

Agriolimax hemphilli ashmuni P. and V.

North of the Grand Canyon in Snake Gulch at Big Spring and Station 49, below the Coconino Smelter; also Station 48.

SUCCINEIDÆ.

Suocinea avara Say.

Bass Station, Grand Canyon R. R.; Grand Canyon on the Mystic Spring Trail along the slope a few hundred feet below the rim, and in the amphitheatre ½ to ¾ mile west of Bass's Camp, on the upper slope; "Spectacle Cove" and Seep Spring, 2 miles west of trail, below cross-bed sandstone; red wall sandstone at 5,000 feet. On the north side of the river we found it along Shinumo Creek, in the box of White Creek, and Ferriss and Daniels took it on the Kaibab Saddle, at Oak Springs, Snake Gulch, Station 11½, at Warm Spring Canyon, Station 59, and the Hurricane Fault, Station 46, 6,000 feet, near Mt. Trumbull.

It lives in a great variety of stations, a large form occurring in humid places, smaller shells in arid situations.

Succinea retusa Lea.

The Greens, 6 miles west of Kanab, Utah; Deception Lake, northwest of Kanab.

Succinea hawkinsi Baird.

The Greens, 6 miles west of Kanab, Utah. The specimens seem to be typical of this very rare and distinct species, here first reported from so far south.

Succinea grosvenori Lea.

North of the Grand Canyon at Big Spring, Snake Gulch, Station 78; Antelope Valley, Station 40, on ant hills; Finley Reservoir near Mt. Trumbull, and at the northwest base of the same mountain.

FERUSSACIDÆ.

Cochlicopa lubrica (Müll.).

Grand Canyon: Bright Angel Trail, from a short distance below the rim to the foot of the cross-bed sandstone and at the Indian Gardens. Mystic Spring Trail on the Spectacle Cove talus, Station A, and near Seep Spring, about 2 miles west of the trail, both places at the base of the cross-bed sandstone.

PUPILLIDÆ.

Pupoides marginata (Say).

Finley's reservoir near Mt. Trumbull.

Pupoides hordacea (Gabb).

Spring on the northwestern side of Mt. Trumbull and at Finley's reservoir; Antelope Valley.

Pupilla syngenes (Pilsbry).

Pupa syngenes Pils., Nautilus, IV, p. 3, May, 1890; V, p. 39, pl. 2, figs. 1, 2. Proc. Acad. Nat. Sci. Phila., 1890, p. 296, pl. 5, figs. 1, 2 (Arizona); 1900, p. 606, with form *dextroversa* P. and V. (San Rafael, N. M.).
Pupa syngenes Dall, Nautilus, VIII, p. 35 (Beaver Creek, Montana).

This sinistral species was based on specimens from Arizona, the exact locality unknown, fully described and figured in these PROCEEDINGS for 1890. Ten years later a dextral form was noted. Specimens of *P. syngenes* are before us from San Rafael and Grants, N. M., and Holbrook, Jerome, Purtyman's ranch on Oak Creek, and the Grand Canyon, Arizona. Dall has reported it from Beaver Creek, Mont., but none are known from Wyoming, Colorado or Utah.

Fig. 6.—*Pupilla syngenes dextroversa*. San Rafael, N. M.

In *Pupilla* it is obvious that dextral forms are the more primitive, the sinistral forms derived from them. *P. syngenes dextroversa*, therefore, perpetuates the original stock of the species, of which *P. syngenes* is a divergent branch.

P. s. dextroversa (fig. 6) is subcylindric, a little wider near the upper end. The last whorl is flattened laterally, with a strong rounded crest and a deep constriction behind the lip, which is thin and very narrowly expanded. The parietal lamella is slightly over one-fourth of a whorl long; the columellar lamella small and deeply immersed and the lower palatal nodule well-developed or weak, but invariably present in adult shells. The size varies.

Length 4, diam. 1.7 mm., whorls 9.
" 3, " 1.6 " " 7½.

P. s. dextroversa differs from *P. blandi* by its larger, comparatively narrower and more cylindric shape, and the greater number of whorls. The two forms were doubtless of common ancestry.

Types of *P. s. dextroversa* are No. 79,460 A. N. S. P., from San Rafael, N. M., collected by E. H. Ashmun. Also taken at Holbrook, Ariz. (Ashmun), at Grants, N. M. (Joshua Baily, Jr., and Albert Baily), and in the Grand Canyon of the Colorado, see below.

The specimens from San Rafael and Holbrook are mirror images of the sinistral *P. syngenes* found with them. At Grants very few were found, no sinistral ones with them.

It appears, therefore, that some colonies of the older dextral form occur unmixed with sinistral, and sometimes the sinistral form is found unaccompanied by dextral.

Our records of *P. syngenes* in the Grand Canyon follow.

North of the Grand Canyon Ferriss and Daniels took *P. syngenes* at Station 25, Powell Plateau; Stations 100, 5 and 7 on the Kaibab-Powell saddle; and at Station 66, Kaibab Plateau. It was associated with form *dextroversa* at Stations 5 and 7, near the "Stone House."

Grand Canyon at the Bright Angel Trail, about 100 feet below the rim. *P. syngenes* and *P. s. dextroversa*, 19 of the former, 12 of the latter, normal in shape, most adults having a palatal tubercle. *P. syngenes* was also taken near the base of the cross-bed sandstone, one specimen.

Mystic Spring or Bass Trail. At Spectacle Cove (Station A), on the *Oreohelix* talus, below the cross-bed sandstone, 103 examples of *P. syngenes* from half-grown to adult were taken, all of them sinistral. Adults vary from 3 mm. long with 7 whorls to 3.7 mm. with 8 whorls. Most of them are triplicate, the columellar lamella and lower

palatal fold distinct. The larger ones from this place are typical in shape; the smaller are shorter than *syngenes* from any other locality in our series.

Fig. 7.—*Pupilla syngenes* Pils. Spectacle Cove, near Bass Trail. Lengths 3.8, 3.5 and 3.2 mm.

Along the upper slope of the Bass or Mystic Spring Trail, Station 2, there is an extensive colony of syngenid forms. We found them most abundant in the humus, among low brushwood, about 200 feet below the rim. Two forms occur here together, a dextral form, *P. s. dextroversa*, and a sinistral, *P. s. avus*, described below, in about equal numbers, 272 of the former and 256 of the latter in the lot collected.

The *P. s. dextroversa* are typical in shape, but larger than the types; the crest is wide and rather far from the lip-edge; a lower palatal tooth is developed. Specimens measure:

Length 4.5, diam. 1.8 mm., whorls 10.
" 3.7, " 1.8 " " 9.

Fig. 8.—*Pupilla syngenes* form *dextroversa* P. and V. Bass Trail, about 200 feet below the rim. Lengths 4.5 and 3.75 mm.

The last is the smallest adult seen from this place; most examples are over 4 mm. long. Specimens of this lot are figured, fig. 8.

At about the same elevation about ½ or ¾ mile west of Bass's Camp a similar specimen of *dextroversa* was taken.

Pupilla syngenes avus n. subsp. Fig. 9.

Shell sinistral, the last whorl deviating tangentially and ascending; teeth deeply immersed; *parietal lamella much longer* than in *P. syngenes* or *dextroversa*, about a half-whorl long.

Length 5.2, diam. 1.8 mm., whorls 10½.
" 4.3, " 1.7 " " 9½.
" 4.0, " 1.7 " " 9½.

Types No. 94,220 A. N. S. P., from upper slope of the Grand Canyon along the Mystic Spring or Bass Trail, about 200 feet below the rim, Station 2; abundant with *P. s. dextroversa*.

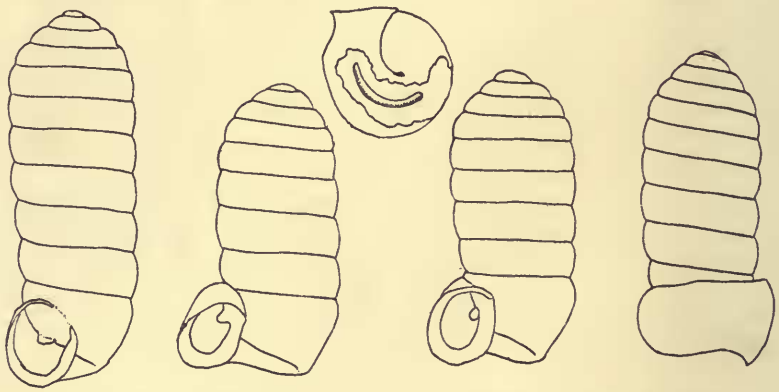

Fig. 9.—*Pupilla syngenes avus*, Cotypes. Lengths 5.2, 4, 4 and 4.2 mm.

The special characters of this race, being those of senility, are unequally developed in different individuals. The figures give a fair idea of the variations. Finding these shells associated with about an equal number of *P. s. dextroversa* of about the same size, we at first were disposed to think them all one race in which the shell was indifferently dextral or sinistral; but on closer study it appears that the dextral forms never have the last whorl and aperture abnormal nor are the teeth so deeply immersed, or the parietal lamella so long, while almost every sinistral shell collected in this colony is markedly distorted. It seems, therefore, that although the two forms are of common origin and live together, the different direction of the coil probably prevents interbreeding, thus segregating the sinistral stock, which in this colony is now in a late stage of senile degeneration.

Pupilla hebes (Anc.).

Pupa hebes Anc., Pils. and Van., Proc. Acad. Nat. Sci. Phila., 1900, p. 589, pl. 22, figs. 9, 10.

Bill Williams Mountain.

Pupilla hebes kaibabensis n. subsp.

The shell is constantly much shorter than the typical form, length 2.7 to 2.8, diam 1.5 mm., whorls 5½. Kaibab Saddle, Station 100, types No. 103,283 A. N. S. P., collected by Ferriss and Daniels, 1909. Also Station 105 in the same region.

Bifidaria quadridentata Sterki.

Bill Williams Mountain.

Bifidaria pellucida hordeacella (Pils.).

Near the Mystic Spring Trail at Station A, on the *Oreohelix* talus, Spectacle Cove.

Bifidaria pilsbryana Sterki.

Bill Williams Mountain. Grand Canyon at the Bright Angel Trail about 100 feet below the rim; Mystic Spring Trail, Station A. Also north of the Grand Canyon at Stations 7, 12, 100 in the region of the Powell-Kaibab Saddle; Station 66, north of Warm Spring Canyon; and at a spring on the northwestern side of Mt. Trumbull.

Bifidaria ashmuni Sterki.

Bright Angel Trail, about 100 feet below rim. North of the Grand Canyon at Stations 7 and 12, Kaibab-Powell Saddle; Station 100, near Oak Springs; and at Mt. Trumbull. These places are all far north of its previously known range.

Vertigo concinnula Ckll.

Bill Williams Mountain.

Vertigo coloradoensis arizonensis Pils. and Van.

Bill Williams Mountain.

VALLONIIDÆ.

Vallonia cyclophorella Anc.

Bill Williams Mountain. Grand Canyon about 200 feet below the rim and at the Indian Gardens, Bright Angel Trail. North of the Grand Canyon at Stations 1, 12, 106 and Oak Springs on the Kaibab-Powell Saddle; Quaking Asp Canyon; Rigg's Springs, Snake Gulch; Warm Spring Canyon; spring on the northwest side of Mt. Trumbull. A common shell in Arizona north of the Grand Canyon.

Vallonia perspectiva Sterki.

Grand Canyon at Seep Spring two miles west of the Mystic Spring

Trail, below the cross-bed sandstone, and in "Spectacle Cove," Station A, at about the same level. It was not taken north of the Grand Canyon.

LYMNÆIDÆ.

Lymnæa parva Lea.

Pipe Spring, Ariz.

Lymnæa obrussa Say.

Deception Lake near Kanab, Utah, small, slender specimens.

Planorbis tenuis Phil.

Reservoir back of Williams, Ariz.

Planorbis deflectus Say.

Fredonia, Ariz., Station 38, near the Utah boundary.

PHYSIDÆ.

Physa virgata Gld.

Reservoir back of Williams; Pipe Springs, Vermilion Cliffs, Station 39. *Physa traskii* Lea and *Ph. orbignyana* Lea are synonymous with *virgata*.

Physa humerosa Gld.

Indian Gardens on the Bright Angel Trail in the Grand Canyon (C. M. Cooke). A small form, evidently referable to this species.

Physa gyrina Say.

The Greens, near Kanab, Utah. Another small *Physa* of uncertain identity was taken in Deception Lake, Utah.

SPHÆRIIDÆ.

Pisidium sp. undet.

The Greens, Kanab Creek, near Kanab, Utah.

Explanation of Plates XII, XIII, XIV.

Plate XII.—Figs. 1–14.—*Oreohelix yavapai profundorum* P. and F. Cotypes. Spectacle Cove. No. 103,234 Acad. Nat. Sci. Phila.

Figs. 15–17.—*Oreohelix yavapai extremitatis* P. and F. Station C, Upper talus, west of Bass Camp. No. 103,237.

Figs. 18–21.—*O. y. extremitatis* P. and F. Cotypes. 100–400 feet below the rim along the trail near Bass Camp. No. 103,236.

Figs. 22–24.—*Oreohelix yavapai angelica* P. and F. Cotypes. 100–400 feet below the rim. Bright Angel Trail. No. 103,239.

Fig. 25.—*O. y. angelica*. Same locality. No. 103,241.

Figs. 26–28.—*Sonorella coloradoensis* (Stearns). Whitish, bandless form from White Creek, 1 mile above its junction with Shinumo Creek, Grand Canyon, north side. No. 103,255.

Figs. 29, 30.—*Sonorella coloradoensis* (Stearns). Head of Starvation Tank Wash, Grand Canyon, south side.

PLATE XIII.—*Oreohelix strigosa depressa* Ckll.—Figs. 1, 3, 5.—Jacobs Canyon, Station 69. No. 103,208 Acad. Nat. Sci. Phila.
Figs. 2, 4.—Jacobs Canyon, Station 70. No. 103,143.
Figs. 6, 7.—First gulch opening west above Warm Spring Canyon, Station 66. No. 103,141.
Fig. 8.—Warm Spring Canyon, Station 62. No. 103,138.
Fig. 9.—Warm Spring Canyon, Station 61. No. 103,116.
Figs. 10–12.—Shinumo Canyon, Station 50. No. 103,148.
Figs. 13–15.—Shinumo Canyon, Station 55. No. 103,197.
Fig. 16.—Moquitch Gulch, Station 76. No. 103,205.
Figs. 17, 18.—Moquitch Gulch, Station 75. No. 103,204.
Figs. 19–21.—Castle Spring, Snake Gulch, Station 79. No. 103,172.
Figs. 22, 23.—Quaking Asp Canyon, Station 91. No. 103,226.
Figs. 24–26.—Quaking Asp Canyon, Station 98. No. 103,157.
Figs. 27, 28.—Head of Quaking Asp Canyon, Station 84. No. 103,161.

PLATE XIV.—*Oreohelix strigosa depressa* Ckll.—Figs. 1–4.—North end of Powell Plateau, Station 17. No. 103,186.
Figs. 5–9.—North end of Powell Plateau, Station 15. No. 103,179.
Figs. 10, 11.—North end of Powell Plateau, Station 18. No. 99,158.
Figs. 12–15.—West side of Powell Plateau, Station 16. Nos. 94,159 and 103,188.
Fig. 16.—West side of Powell Plateau, Station 19. No. 103,180.
Figs. 17–21.—East side of Powell Plateau, Station 103. No. 103,188.
Figs. 22, 23.—North end of Powell Plateau, Station 105. No. 103,177.